# Got a Water Problem?

## Lawrence Livermore National Laboratory Can Help: Supply and Quality Management, Diagnostics, and Cleanup

The growing demand for water is putting pressure on the world's limited resources, threatening economic development and even future political stability. Water resources agencies face the task of assessing the availability and quality of future water supplies. Storage, distribution, and purification systems need improved management and technologies; the increased use of recycled treated waste-waters requires more stringent water quality analyses; and conflicts between urban, industrial, agricultural, and environmental concerns need resolution. Lawrence Livermore National Laboratory has unique capabilities to provide integrated solutions for managing precious water resources:

- Science-based strategic planning for managing regional water supply and quality.
- Evaluation of options for characterizing and remediating contaminated groundwater.
- Measurement of the effectiveness of remediation treatment.

The Laboratory's location in California gives it an excellent testbed; the state has one of the most sophisticated surface-water storage and delivery systems in the world. Even here, however, uncertainties make water management difficult over both the short and the long term (planning for the effects of flooding versus drought, for example). Balancing immediate near-term needs against the long-term viability of the state's water resources is an especially important and complex issue for water resource managers.

At the Laboratory, novel application of our interdisciplinary strengths in computer modeling, engineering, and chemical analysis and processing is providing new tools for water resource management:

- *Computer simulations*
  - Impacts of regional climate on local-scale surface-water hydrology and quality.
  - Groundwater motion and quality in large aquifer systems and its interaction with surface water.
- *Diagnostics*
  - Isotopic measurements for determining the age of water, its sources and flow paths, and its quality.
  - Sensors to measure multiple contaminant constituents on site.
- *New, proven technologies for remediation and desalting*
  - Capacitive Deionization for water purification.
  - Dynamic Underground Stripping for removing underground contaminants above and below the water table.
  - Biofilters for in-place destruction of organic compounds.

For more information about how Lawrence Livermore National Laboratory can help with water management, contact:

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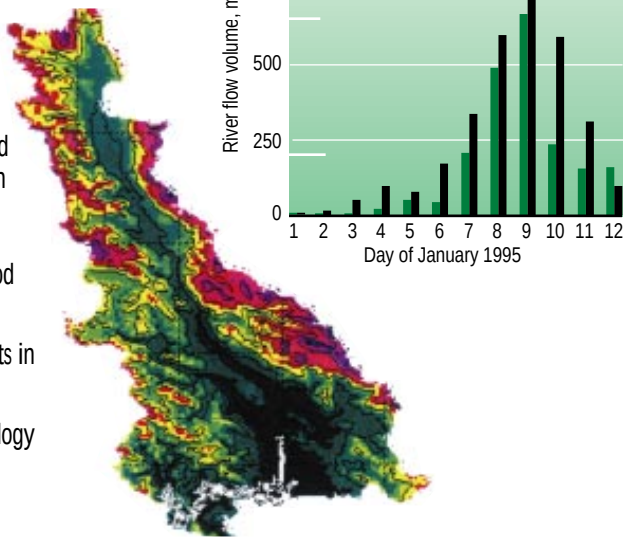
The Laboratory is on the World Wide Web at http://www.llnl.gov.

# Computer Simulations in 3D and Real Time

## Atmospheric and Surface Hydrology

Our hydrology modeling uses a unique coupled approach for linking short-term precipitation forecasts to river flow predictions to provide a reliable, real-time basis for making decisions about flood and reservoir management. A combination of three models incorporates data such as precipitation predictions, topography, physiology of seasonal plant species, and water distribution among soil layers, plants, and existing snowpack. The system is being used successfully on the Russian River watershed for short-term weather and river stage predictions and for seasonal hydrometeorological research, and is being tested in other areas. We collaborate with:






- The National Weather Service. Our system predicted the Winter 1995 Russian River flood stage with 90% accuracy.
- The Korean Meteorological Research Institute. We are participating with Korean scientists in a NASA/National Weather Service study of the southeast Asia monsoon.
- Scripps Institution of Oceanography. We are jointly developing a new-generation hydrology model and compiling a database for the California surface hydrology cycle.

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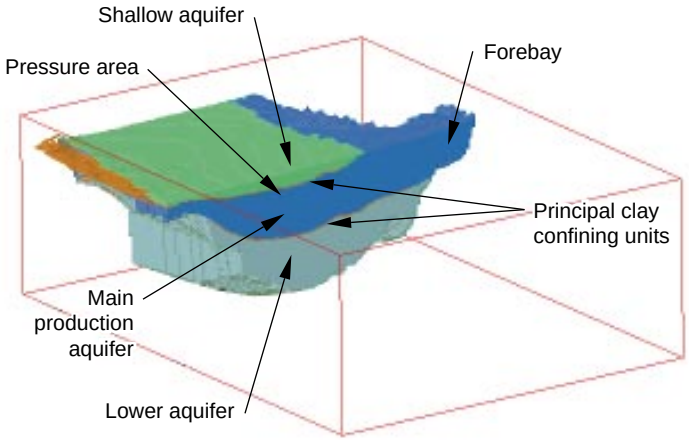
## Groundwater Flow

We have unique capabilities to simulate groundwater flow and chemical transformations in large, complicated, three-dimensional subsurface formations. Our models have been used to study and forecast the evolution and remediation of groundwater pollution, as well as to analyze the supply and quality of water in regional aquifer systems. We are applying the model to a coastal groundwater basin in Orange County that supplies more than 70% of the needs of 2 million residents; the Water District plans to accelerate its groundwater management program by recharging additional treated wastewaters into existing infiltration basins, pumping increased supplies as a result. We are helping to address concerns such as:




- Which wells may produce the "recycled" groundwater, and when?
- How and where is the quality of the groundwater affected by the recharged wastewaters?
- How will increased production in the basin affect the existing saltwater barriers (composed of injection wells) near the coast?

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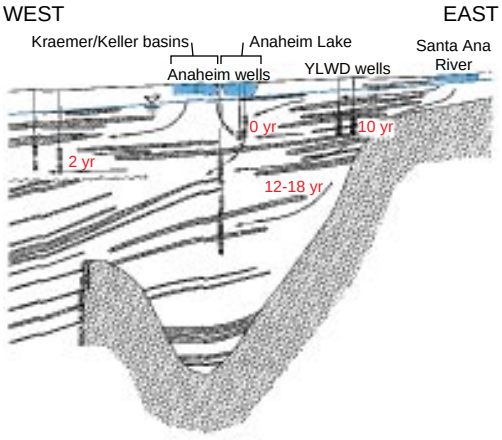
# Diagnostics

## Isotopic Sciences




The isotopes found in water can be used as a powerful diagnostic tool to fingerprint sources of surface and groundwater, track their travel pathways and flow rates, and assess origins of the water's chemical constituents. We operate a variety of sophisticated facilities for measuring the most minute isotopic compositions on a regular "production mode" basis—no other laboratory has as wide a range of capabilities. Our work has included studies funded by:

- The Orange County Water District. We identified the isotopic fingerprint of recycled water—showing, for example, that injected wastewater at salt-water barrier wells took 2.5 years to reach the nearest production well, satisfying the requirement for 1-year residence time.
- The City of Brentwood and the East Contra Costa Irrigation District. Our results provided a quantitative framework for better assessing the long- and short-term sustainability of their groundwater resources under various land-use scenarios.
- The U.S. Army, Sierra Army Depot. We developed a groundwater flow model from isotope data in the Honey Lake basin. We quantified groundwater recharge rates and predicted the impact that proposed groundwater transfers to Reno would have on the migration of contaminants below the Army's weapons-decommissioning site.

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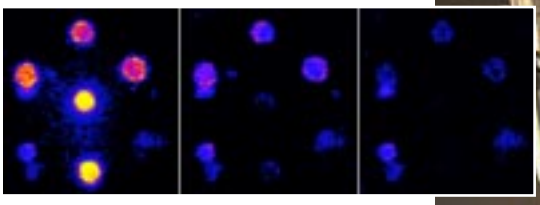
## Sensors

We have a portable, low-cost instrument that uses multiple sensors placed in a single optical fiber to measure the concentrations of chemical constituents in place, saving time and expense because samples do not have to be collected and sent to laboratories for analysis. Its capabilities include:

- Simultaneous measurement of multiple compounds to the parts-per-million level.
- Hardiness to environments with high levels of radiation, magnetic flux, or temperature variation.



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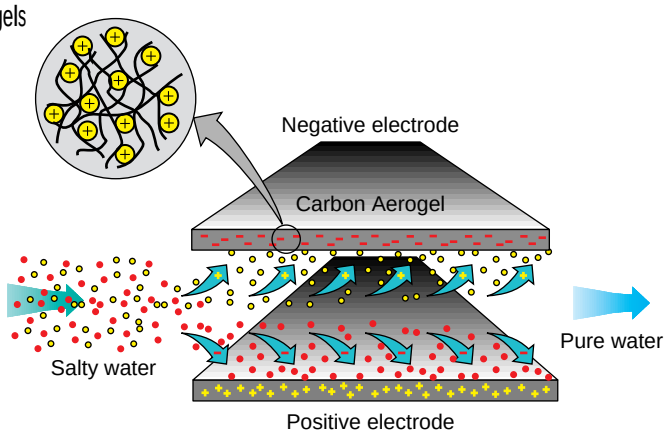
Work performed by Lawrence Livermore National Laboratory under the auspices of the U.S. Department of Energy under Contract W-7405-Eng-48.

# Technologies for Remediation

## Capacitive Deionization

This efficient and economical process for purifying water uses the new carbon aerogels as electrostatic filters. The technology can be applied to wastewater treatment, water purification, water softening, and desalination. The automated user-friendly control system can run purification plants with capacities of hundreds to millions of gallons per day. The process has compelling advantages:

- Energy efficiency—far better than competing technologies.
- Electrostatic regeneration of filters—no need for acids, bases, or salt solutions.
- Excellent stability in harsh chemical conditions.

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## Dynamic Underground Stripping

This is the first remediation technology that has been able to remove separate-phase contaminants (such as free-product gasoline) below the water table. It uses steam and electric heating combined with vacuum extraction. The results exceed our expectations: in a commercial-scale application at the site of a large gasoline spill, it not only removed the free-product gasoline, it cleaned much of the groundwater to drinking water standards. It also:

- Can clean up solvents, metals, and large-area plumes.
- Works in low-permeability soil.
- Remediates quickly and at affordable cost—no long-term investment.

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## Biofilters

"Bioremediation" of contaminated aquifers uses naturally occurring microorganisms to degrade organic contaminants to harmless compounds. The contaminants are destroyed in place, not relocated. Our revolutionary microbial filters—established by specially cultured microbes injected into the subsurface—avoid problems encountered in other bioremediation processes. A successful demonstration at Chico Municipal Airport showed that the biofilters:

- Provide much cheaper cleanup than pump-and-treat.
- Can target specific contaminants.
- Need only minimal maintenance.

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